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Foreword

Alhamdulillah. First of all a big thank you and congratulations to the Editorial Board of *Esteem Academic Journal* of Universiti Teknologi MARA (UiTM), Pulau Pinang for their diligent work in producing this issue. I also would like to thank the academicians for their contributions and the reviewers for their meticulous vetting of the manuscripts. A special thanks to University Publication Centre (UPENA) of UiTM for giving us this precious opportunity to publish this first issue of volume 5. In this engineering issue we have upgraded the standard of the manuscript reviewing process by inviting more reviewers from our university as well as other universities in Malaysia. We have embarked from previous volume to establish a firm benchmark and create a journal of quality and this current issue remarks a new height of the journal quality. Instead of publishing once in every two years, now *Esteem* publishes two issues annually.

In this issue, we have compiled an array of 13 interesting engineering research and technical based articles for your reading. The first article is entitled "The Response of Tube Splitting on Circular Tubes by Using Various Types of Semi-angles Dies and Slits". The authors, Mohd Rozaiman Aziz and Roslan Ahmad investigated the axial splitting and curling behavior of aluminum circular metal tubes which was compressed axially under static loading using three types of dies with different semi-angles. The authors concluded that the introduction of slit to the specimen is necessary to initiate slitting rather than inversion.

Salina Budin, Aznifa Mahyam Zaharudin, and Sugeng Priyanto presents a model of energy conversion and impact energy generation during collision based on free falling experiment, which is closely resembles direct collision between ball and inner wall of the vial. Simulation results from the proposed impact energy model demonstrated that the impact energy generated during the collision is strongly influenced by the thickness of the work materials and reaches zero at certain value of the work materials thickness, which increases with an increase of falling height.

Salina Alias, Caroline Marajan and Mohamad Azrul Jemain wrote an article that looks at adsorption of zinc from waste water using bladderwort (*Utricularia vulgaris*). In batch adsorption studies, data show that dried bladderwort has considerable potential in the removal of metal ions from aqueous solution. The fourth article written by

Muhammad Khusairi Osman et al. looked at 3D object recognition using affine moment invariants and Multiple Adaptive Network Based Fuzzy Inference System (MANFIS). The experimental results show that Affine Moment Invariants combined with MANFIS network attain the best performance in both recognitions, polyhedral and free-form objects.

The article entitled "Construction Waste Management Methods Used by Contractors in the Northern Region" authored by Siti Hafizan Hassan, Nadira Ahzahar and Mohd Nasrul Nizam Nasri reports an ongoing study on the use of construction waste management methods by contractors and its impact on waste reduction in the Northern Region. In conclusion, the sizing and amount of materials to be ordered to reduce wastage is significant in reducing construction waste generation waste, alleviating the burden associated with its management and disposal. The sixth article by Muhammad Sofian Abdullah et al. examined on the performance of Performance of Palm Oil Fuel Ash (POFA) with lime as stabilizing agent for soil improvement. The authors concluded that POFA can be used to treat the silty soil as well as to reduce the environmental problem.

The seventh article penned by Soffian Noor Mat Saliah, Noorsuhada Md. Nor and Megat Azmi Megat Johari presents the results of an experimental study on the interfacial bond strength (IBS) of polypropylene fiber concrete (PFC). It was found that the interfacial bond strength between concrete and reinforcement bar was not affected by the inclusion of polypropylene fibers. However, concrete containing fibers exhibited no breaking of concrete and no debonding of reinforcement. The article by Juliana Zaabar and Rusnani measures, evaluates and analyzes the network link performance of fiber optic cable using OTDR. The authors suggested that the major loss for these measurements is connector loss. Preventive maintenance will increase the life time of fiber optic. From some of the findings, the PVC dust cap has been identified as a main source of contamination for the SC connector.

The article entitled "Symbolic Programming of Finite Element Equation Solving for Plane Truss Problem" by Syahrul Fithry Senin proposed a plane truss problem to be solved by finite element method using MAPLE 12 software. The numerical solution computed by the author was almost matched with the commercial finite element software solution, LUSAS. The tenth article by Nor Azlan Othman, Nor Salwa Damanhuri and Visakan Kadirkamanathan presents a detail review of fault diagnosis in rotating machinery using pattern recognition technique. The authors proposed a solution based on artificial neural network (ANNs) which is Multi-Layer Perceptron (MLP). The authors concluded that

the proposed methods are suitable for rotating machinery on fault detection and diagnosis.

The eleventh article is entitled "RAS Index as a Tool to Predict Sinkhole Failures in Limestone Formation Areas in Malaysia". Damanhuri Jamalludin et al. found that, using the RAS classification method, the prediction of sinkhole occurrences can be easily be made by simply knowing the weekly rainfall especially in areas having limestone as the bedrock. The twelfth by Muhammad Hafeez Osman et al. explores cases regarding the histories of rock slope repair and stabilization of unstable boulder along the road from Bukit Cincin to Genting Highland and along the road from Gap to Fraser Hill. The last article is "Soil Nail and Guniting Works in Pahang". The authors, Damanhuri Jamalludin et al. concluded that if the stability of the embankment needs to be improved, soil nails can be installed and embankment surface can be covered with gunite to prevent erosion.

We do hope that you not only have an enjoyable time reading the articles but would also find them useful. Thank you.

Mohd Aminudin Murad
Chief Editor
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(Engineering)

Performance of Palm Oil Fuel Ash (POFA) with Lime as Stabilising Agent for Soil Improvement

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ABSTRACT

Agricultural waste materials have a great potential to be used as chemical stabilizer in the soil stabilization technique. In this research, the performance of Palm Oil Fuel Ash (POFA) was investigated to improve the engineering properties of silty soil by mixing it with the lime slurry under different curing period. Silty soil had been used in this study because it is a problematic soil with low strength. The problem related to this soil is like structure failure due to inadequacy of the soil strength. Objective of this study is to investigate the performance of lime and POFA as the stabilization agent on silty soil. More than hundreds remoulded sample have been prepared based on 1:3 ratio (lime:POFA). These samples were cured for 7, 14, 28 and 60 days. The performance of POFA in stabilizing silty soil is great at the ratio of 2% POFA and 6% lime in the silty soil. The performance of the stabilized silty soil will decrease if the ratio of POFA and lime exceeding 2:6. The strength development of soil treated with lime and POFA is increasing with respect to the curing time. As a conclusion, POFA can be used to treat the silty soil as well as reduce the environmental problem.

Keywords: *Soil stabilization, silty soil, POFA, lime, unconfined compressive test*

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Introduction

Soil improvement is the term used for improving the characteristics of a soil which commonly involve in strength improvement of the soil. There were many type of soil improvement in the geotechnical field today and it was classed in three type of technique which is mechanical, physical and hydraulic method. The soil improvement by using the hydrated lime to stabilize the soil is classed as a physical method. The lime stabilization is more applicable to heavier clayey soils (having plasticity index ranging from 10% to 50%). Soil plasticity, density and strength are changed by the addition of lime to soil. Lime generally increases the plasticity index of low plasticity soils and decreases the plasticity index of highly plastic soils. Due to addition of lime, the soil becomes more friable and easy for handling in the field. In general, it causes a reduction in the maximum compacted density, increase in the optimum moulding water content and strength of soils.

Silty soils have low permeable and are relatively more compressible. There is consensus among engineers and contractors that the traditional remediation techniques such as densification, reinforcement, or solidification (grouting, admixtures) used for sandy soils need to be modified to suite the need for silty soils (Sabanayagam, 2004). The lime stabilizing technique used today also stated that the silty soil may be can be use with lime in soil improvement technique by increasing the amount of pozzolanic material in the soil (Rogers, 1996). Recently, researchers found the pozzolanic material such as palm oil fuel ash (POFA) can be used as cement replacement in concrete because it is highly silica content (Chai et al., 2005). Therefore, this study concentrated on evaluating the performance of POFA as a pozzolanic material in stabilizing the silty soil.

The contribution of this study to the society is that the utilizing of the agro waste such as POFA in soil stabilization techniques and hence reduces the environmental problem related to the agricultural waste management.

Material

Silty Soil

The silty soil was collected at a river bank of Sungai Pertama, Permatang Pauh. The silty soil was oven-dried at a temperature approximately 100°C

for 24 hours before used in test. After that, the silty soil was sieved at 425 μm as a control particle size and then stored in an airtight container.

Lime

Hydrated lime in the slurry form was used in this study to avoid the dust to the environment. Lime to be used in this study was stored in airtight container to control the originality.

Palm Oil Fuel Ash (POFA)

Palm oil fuel ash (POFA) is selected to be used for this study because a large amount of POFA will produce from the palm oil industry. It is also contains a large amount of silica and has high potential to be used as a pozzolanic material. POFA used in this study was collected from an industry located in Kluang, Johor where it was combusted at temperature about 700°C to 1000°C. POFA was sieved through a sieve 63 μm pan opening in order to remove foreign materials and uncompensated palm fibre.

Methodology

The methodology involved in this study can be divided into three stages. The first stage is literature review on several journal papers. The second stage is laboratory work and the last stage is result and discussion. At the laboratory stage, more than hundreds specimen was prepared according to the proportions which have been design. The density of the material is control to provide the good result at the end of study. Mix design is shown in Table 1. There are 3 types of specimen was prepared which are untreated soil, silt soil mix with lime only, silt soil mix with lime and POFA. The entire specimen is cured for 7, 14, 28 and 60 days. The total numbers of specimen's as shows in the Table 2.

Laboratory Work

Physical and Mechanical Properties Test

All the physical properties tests were done according to BS 1377: Part 2:1990. From the test, the soil classification was determined. Hence, the

Table 1: Mixing Proportion of Stabilizer

Lime	POFA:Lime
3% of soil mass	1% POFA and 3% lime of soil mass
6% of soil mass	2% POFA and 6% lime of soil mass
9% of soil mass	3% POFA and 9% lime of soil mass
12% of soil mass	4% POFA and 12% lime of soil mass
15% of soil mass	5% POFA and 15% lime of soil mass

Table 2: Sample Mix and No. of Curing Day

Curing period	Types of specimens	No. of specimens
Immediate test	Untreated soil	
CP 07	Silty soil + Lime	3 x 5 ratio = 15
CP 14		3 x 5 ratio = 15
CP 28		3 x 5 ratio = 15
CP 60		3 x 5 ratio = 15
CP 07	Silty soil + Lime + POFA	3 x 5 ratio = 15
CP 14		3 x 5 ratio = 15
CP 28		3 x 5 ratio = 15
CP 60		3 x 5 ratio = 15

silty soil was the outcome from the soil classification analysis. All the mechanical properties tests were done according to BS1377: Part 4:1990. The tests were followed accordingly as stated in the standard. From compaction test and unconfined compression test it can be shown the strength of the silty soil is weak; which lead to silty soil as problematic soil.

Result and Discussion

Soil Classification

The preliminary test of the research is to determine the parameters that are related with basic physical characteristic of fine soil that are specific gravity, Atterberg limit and the particle size distribution (PSD) of the soil. Table 3 shows the physical properties of the soil tested. The specific gravity value was obtained from the small pycnometer method, the Atterberg limit which is to determine the plastic limit (PL) and liquid limit (LL) were done in the laboratory by using cone penetrometer test for LL and PL is according to the BS 1377. The PSD for the soil in this

Table 3: Physical Properties of Soil Sample Tested

Soil properties	Values of properties
Specific Gravity (Mg/m^3)	2.67
Plastic Limit	28.66
Liquid Limit	43.45
Plasticity Index	15
Particle Size Distribution (Hydrometer test)	Silt, MI

research was done by using the hydrometer test that is suitable for a fine grained soil.

Based on the Table 3, the value of the specific gravity of the soil tested is 2.67 Mg/m^3 which are within the standard range value of specific gravity for silty soil, 2.67 Mg/m^3 to 2.70 Mg/m^3. Therefore, the values obtain from the specific gravity test classes the soil in silty soil type. The plastic limit (PL) and liquid limit (LL) of the soil tested is 28.66% and 43.45% respectively. This value confirmed the soil selected is silty soil (MI).

Compaction Test

Soil Treated with Lime

The compaction test of soil was done by using a various percentage of lime to the weight of soil mass. The result obtain is in the Table 4.

Table 4 shows the result for the compaction test of various ratios of silty soil and lime. From the result, the increasing percentage of lime to the silty soil will increase the optimum moisture content (OMC) where the highest value of OMC is the soil treated with 15% of lime. In the meanwhile, the result for the maximum dry density (MDD) of the treated soil is opposite the result of OMC, as the value of MDD is decreasing with the increasing of lime percentage. The highest value of MDD is for soil treated with 3% of lime and the lowest value of MDD is for the soil treated with 15% of lime. The result obtained shows that the density of soil was affected by lime where the lime will absorb the water and hence decrease the maximum dry density of the soil.

Soil Treated with POFA and Lime

The compaction test of soil treated with lime and POFA were done by using a various percentage of lime and POFA at 1:3 ratio (POFA:Lime). The compaction result for this treated soil as in Table 5.

Table 4: Compaction Test Result After Treated by Various Percentage of Lime

Percentage of lime (%)	OMC (%)	MDD (Mg/m^3)
Untreated soil	18.78	1.80
3	19.07	1.77
6	20.35	1.70
9	21.05	1.65
12	22.04	1.56
15	23.34	1.53

Table 5: Compaction Test Result for Various Percentages of POFA and Lime

Ratio POFA:Lime	OMC (%)	MDD (Mg/m^3)
Untreated soil	18.78	1.80
1:3	18.96	1.77
2:6	20.57	1.72
3:9	21.40	1.63
4:12	22.95	1.54
5:15	24.03	1.50

From the result in Table 5 and Figure 2, the OMC value for soil with 1%, 2%, 3%, 4% and 5% of POFA is 18.96%, 20.57%, 21.4%, 22.95%, and 24.03% respectively. The value pattern of OMC for soil treated with POFA shows a linear decreasing pattern as the POFA increased.

The MDD value of the soil is decreasing with respect to the increasing of POFA. From this result, it shows that the present of POFA in the soil treated have also promoted the decreasing of MDD value of the soil.

Unconfined Compressive Test (UCT)

The unconfined compressive test (UCT) is use to measure the strength and hence evaluates the performance of treated soil. The specimens prepared for this test as shown in Table 2. The results for soil treated with lime are shown in Table 6.

From the result in Table 6, the compressive strength of silty soil is increase with respect to the increasing of the lime percentage and curing time. The strength of soil treated with lime at day 7 of curing time is much lower than the strength at 60 days curing time.

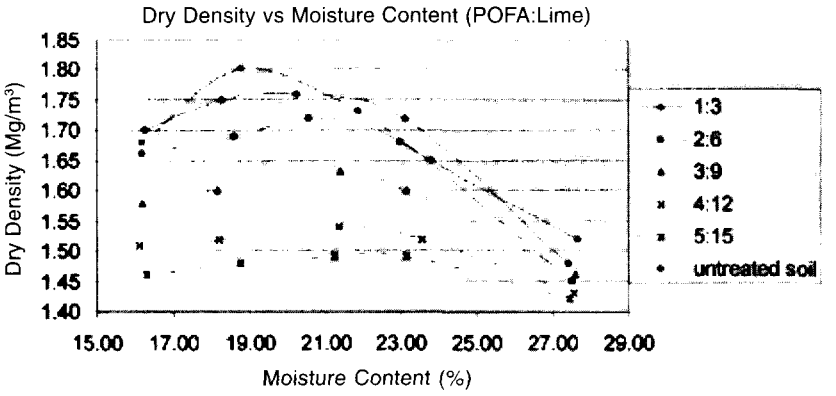

Figure 2: Compaction Test for Various Ratios of POFA and Lime

Table 6: Unconfined Compression Strength of Soil Treated with Lime

Soil: Lime	Curing time (day)			
	7	14	28	60
1:3	710	785	815	918
1:6	787	846	934	1043
1:9	854	915	980	1130
1:12	905	964	1065	1204
1:15	930	980	1125	1215

At 7 days of curing time the result of compressive strength for 3% of lime added to silty soil is 710 kPa, which is about 28.17% value increase compared to the untreated silty soil that have only 510 kPa compressive strength and then the compressive strength is increase to 930 kPa after added with 15% of lime into silty soil and result 45.16% value increase compared to the untreated silty soil. The compressive strength of treated sample for 3% lime and for 15% lime at 60 days is 918 kPa and 1215 kPa respectively, which is 44% increment of compressive strength. The compressive strength of the treated soil seem to be increase due to curing period which is the longer curing period the higher compressive strength.

The Influence of POFA and Lime

There are 5 different ratios of POFA and lime contents that were used to evaluate the performance of silty soil treated with POFA and lime, as

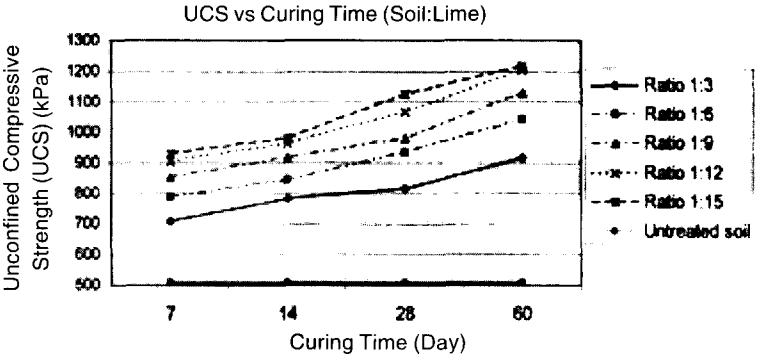

Figure 3: Unconfined Compressive Strength Against of Silty Soil Treated by Lime

Table 7: Unconfined Compressive Result for Different Percentage Lime with Respect to Curing Time

Lime content	Curing time (day)			
	7	14	28	60
3%	710	785	815	918
6%	787	846	934	1043
9%	854	915	980	1130
12%	905	964	1065	1204
15%	930	980	1125	1215

shown in Table 2. The samples are cured for 7, 14, 28 and 60 days to evaluate the effect of curing period of POFA and lime stabilized soil.

The result of UCT for the soil treated with POFA and Lime are shown in Table 8 and Figure 5 which is the value of compressive strength is higher than the soil treated with lime. The value of compressive strength increases smoothly from 7 days to 28 days curing time and become rapid after 28 days. This is due the modification and stabilization process. From 7 to 28 days, there are some arrangements of soil particle together with lime and POFA. After 28 days this compound become stable and the stabilization process occur.

The sample show an unstable pattern of compressive strength development for the ratio of 3:9 treated sample where it is about 17.73% value increase at 28 days curing compare to the 7 days curing period. The result shows that the reaction between soil, lime and POFA is unstable at the ratio 3:9 (POFA: Lime).

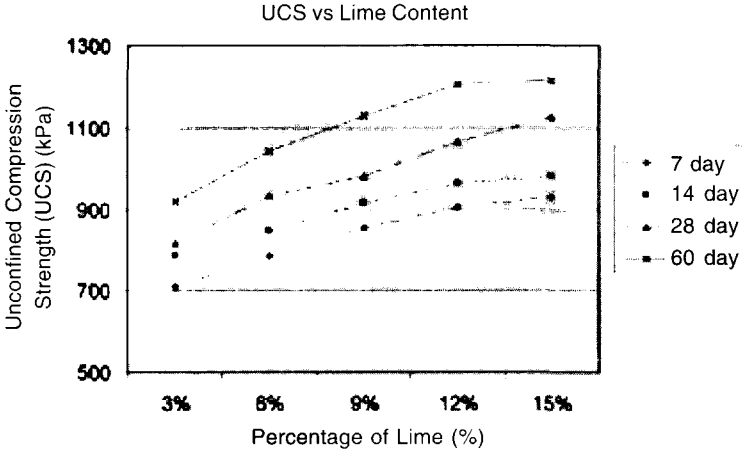

Figure 4: Unconfined Compressive Strength Against Lime Content

Table 8: Unconfined Compressive Result at Different Ratios of Lime and POFA

Lime: POFA	Curing time (day)			
	7	14	28	60
1:3	725	785	832	1185
2:6	810	885	947	1232
3:9	835	945	1015	974
4:12	765	805	833	911
5:15	610	756	785	812

Conclusions

In general, based on the result obtain POFA can be used together with lime as a stabilizing agent for silty soil. The performance POFA in stabilizing silty soil is great at the ratio of 2% POFA and 6% lime in the silty soil. As observed, the strength of the specimen decrease if the ratio of POFA and lime exceeding 2:6 ratio. The optimum percentage of lime and POFA to stabilize the silty soil is 6% and 2% of the soil mass respectively. The strength development for both treated soil is increasing with respect to the curing time and the best result is at 60 days curing time. This phenomenon may be due to the rearrangement of particle whereby the void becomes closer.

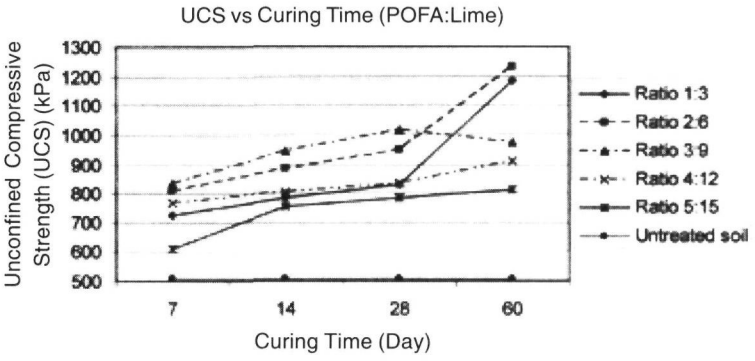

Figure 5: Effect of Curing Time for Silty Soil Treated with POFA and Lime

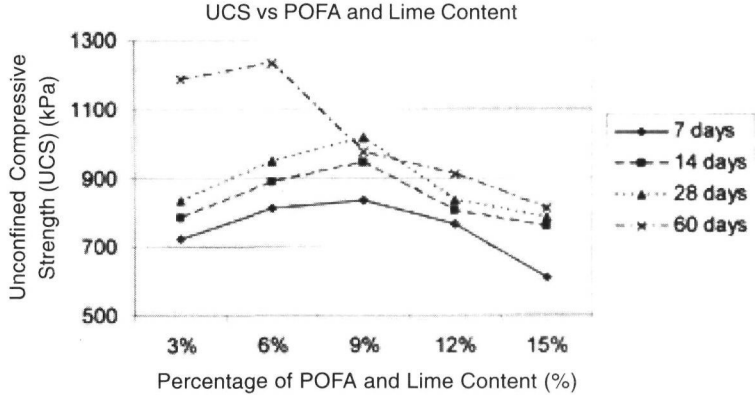

Figure 6: Influence of Lime and POFA to the Treated Silty Soil

As a conclusion, by using agricultural waste as a stabilizer material will give a good achievement in reducing the construction cost due to cut and fill process and usage of low amount of lime for stabilizing silty soil. The utilization of the POFA can also have the potential of saving the precious time due to shorter construction time and no need transporting like cut and fill process and it also reduce pollution or garbage gaining ground due to bulking of agricultural waste.

References

Attoh, O. (1995). *Lime treatment of – revisited*, Department of Civil and Environmental Engineering, Florida International University, University Park Campus, Miami, FL 33199, USA.

Awal, A., & Hussin, M. W. (1997). *The effectiveness of palm oil fuel ash in preventing expansion due to alkali-silica reaction.* Faculty of Civil Engineering, Universiti Teknologi Malaysia, Skudai, Johor Bahru, Malaysia.

Basiron, Y. (2002). Palm oil and its global supply and demand prospects, *Oil Palm Industry Economic Journal*, *2*(1).

British Standard Institution. (1990). BS 1377-2. *British Standard. Methods of test for soils for civil engineering purposes.* London, UK: British Standard Institution.

British Standard Institution. (1990). BS 1924: PART 1, *British Standard, Stabilized materials for civil engineering purposes, general requirements, sampling, sample preparation and tests on materials before stabilization.* London, UK: British Standard Institution.

British Standard Institution. (2001). BS 6463: Part 102, *British Standard, Quicklime, hydrated lime and natural calcium carbonate; methods for chemical analysis.* London, UK: British Standard Institution.

Chai, J., Kraiwood, K., Weerachart, T., Tirasit, S., & Anek, S. (2005). *Use of waste ash from palm oil industry in concrete,* Department of Civil Engineering, King Mongkut's University of Technology Thonburi, Thailand.

Chai, J., Kraiwood, K., Weerachart, T., & Tirasit, S. (2006). *Evaluation of the sulfate resistance of concrete containing palm oil fuel ash,* Department of Civil Engineering, Faculty of Engineering, King Mongkut's University of Technology Thonburi, Thailand.

Chindaprasirt, P., Rukzon, S., & Sirivivatnanon, V. (2006). *Resistance to chloride penetration of blended portland cement mortar containing palm oil fuel ash, rice husk ash and fly ash.* Department of Civil Engineering, Faculty of Engineering, Khon Kaen University, Khon Kaen 40002, Thailand.

Gary, H.R. (2002). *Alaska soil stabilization design guide,* Department of Civil Engineering Oregon State University Corvallis, Oregon.

Head, K. H., (1992). *Manual of soil laboratory testing, 2nd Ed., Volume 1, Soil Classification and Compaction Tests*, PENTEC Press London.

National Lime Association (January 2004). *Lime-treatment soil construction manual, lime stabilization and lime modification*, Bulletin 326. New York.

National Lime Association (March 2001). *Using lime for soil stabilization and modification,* Bulletin 326. New York.

Rees, D. G. (2000). *Stabilised soil tanks for rainwater storage.* Development Technology Unit, University of Warwick.

Rogers, C. D. F. (1996). *Lime stabilization,* (Ed.). London: Thomas Telford.

Thevanayagam, S. (2004). *Ground remediation for silty soils using stone columns geotechnical and foundation engineering*, University at Buffalo.

Ulrich, S. (2002). *Geotechnical engineering handbook (Vol. 1): Fundamental.* Ernst & Son.